

LETTER



Transpulmonary driving pressure, without esophageal pressure measurements, instead of airway driving pressure

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Dear Editor,

In a recent letter, the relative strength of association of mechanical power and driving pressure (ΔP) with mortality was assessed [1]. Both the mechanical power concept and the driving pressure approach rely on airway driving pressure (ΔP_{AW}), i.e., driving pressure of the respiratory system, but it is the transpulmonary driving pressure (ΔP_{TP}), which is the pressure that “hits” the lung and therefore one of the major factors of ventilator-induced lung injury (VILI). The Gattinoni group has shown in patients with acute respiratory distress syndrome (ARDS) subjected to a PEEP trial, that the overall $\Delta P_{TP}/\Delta P_{AW}$ was 0.71, but ranged from 0.36 at PEEP 5 cmH₂O in patients with extrapulmonary ARDS, to 0.98 at PEEP 15 cmH₂O in patients with pulmonary ARDS [2]. In ten ARDS patients, $\Delta P_{TP}/\Delta P_{AW}$ ranged from 0.28 to 0.76 during a PEEP trial with PEEP steps 0–4–8–12–16 cmH₂O [3] (Fig. 1).

This indicates that for an individual patient, it is important to use transpulmonary driving pressure, rather than airway driving pressure as a rational basis for protective ventilation [4]. There is a notion that this requires esophageal pressure measurements, which are neither easy, nor simple, and would never be possible to use in all patients. However, we have shown, that the change in end-expiratory lung volume (EELV) following a PEEP increase is determined by the size of the PEEP step and the elastic properties of the lung only (EL), $\Delta P_{EEP}/EL$ [3, 5]. Consequently, lung elastance can be determined as $\Delta P_{EEP}/\Delta EELV$, if $\Delta EELV$ is measured by the ventilator during a simple one-PEEP-step up and down procedure from

baseline clinical PEEP, where the procedure is finalized by setting the tidal volume equal to $\Delta EELV$ [3, 5]. During such a measurement procedure, end-expiratory transpulmonary pressure (PTPEE) increases as much as PEEP is increased, i.e., $\Delta PTPEE = \Delta PEEP$, which means that end-expiratory transpulmonary pressure is equal to PEEP, $PTPEE = PEEP$. Transpulmonary driving pressure of the tidal volume equal to the change in EELV is equal to the change in PEEP, $\Delta P_{TP} = \Delta PEEP$ [3, 5], and end-inspiratory transpulmonary pressure is equal to $PEEP + \Delta PEEP$. Thus, the one-PEEP-step up and down procedure provides both transpulmonary driving pressure and end-inspiratory transpulmonary plateau pressure without esophageal pressure measurements.

If the measurement procedure is extended to a two-PEEP-step procedure, a best-fit lung P/V curve can be calculated from end-expiration at baseline PEEP to end-inspiration of the highest PEEP level, covering the transpulmonary pressure range that is acceptable from a VILI point of view. The tidal lung P/V curve, of any tidal volume, moves up and down this lung P/V curve, which makes it possible to determine the PEEP level, where the transpulmonary driving pressure is lowest, irrespective of the size of the tidal volume, from the best-fit lung P/V curve [5] (for details, see e-supplement).

The measurement procedure can easily be implemented and automatized in any ventilator’s software and used in trials where the effect of reduced mechanical power is compared with PEEP setting where transpulmonary driving pressure is lowest (least injurious).

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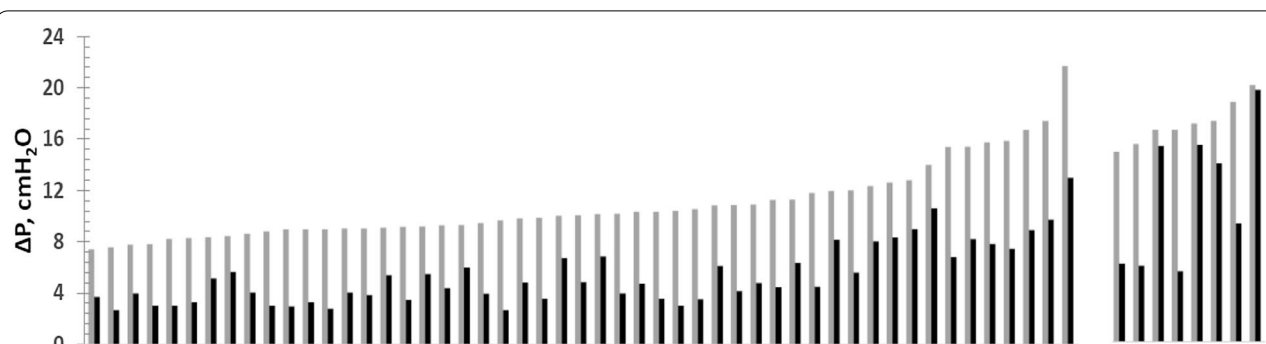


Fig. 1 Airway driving pressure (gray bars) and transpulmonary driving pressure (black bars) in 10 individual patients during a PEEP trial 0–4–8–12–16 cmH₂O (left part of diagram) [3] and mean of nine patients with pulmonary ARDS and 12 patients with extrapulmonary ARDS, undergoing a PEEP trial 0–5–10–15 cmH₂O [2]. The ratio of $\Delta PTP/\Delta PAW$ changes when PEEP is changed in all patients and the overall ratio varies between patients and makes ΔPAW a less suitable predictor of ΔPTP

Electronic supplementary material

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Compliance with ethical standards

Conflicts of interest

OS holds share in the Lung Barometry AB.

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References

1. Tonna JE, Peltan I, Brown SM, Herrick JS, Keenan HT, University of Utah Mechanical Power Study Group (2020) Mechanical power and driving pressure as predictors of mortality among patients with ARDS. *Intensive Care Med*. <https://doi.org/10.1007/s00134-020-06130-2>
2. Gattinoni L, Pelosi P, Suter PM, Pedoto A, Vercesi P, Lissoni A (1998) Acute respiratory distress syndrome caused by pulmonary and extrapulmonary disease. Different syndromes? *Am J Respir Crit Care Med* 158:3–11
3. Lundin S, Grivans C, Stenqvist O (2015) Transpulmonary pressure and lung elastance can be estimated by a PEEP-step manoeuvre. *Acta Anaesthesiol Scand* 59:185–196
4. Tonetti T, Vasques F, Rapetti F, Maiolo G, Collino F, Romitti F, Camporota L, Cressoni M, Cadringer P, Quintel M, Gattinoni L (2017) Driving pressure and mechanical power: new targets for VILI prevention. *Ann Transl Med* 5:286–386
5. Stenqvist O, Persson P, Lundin S (2018) Can we estimate transpulmonary pressure without an esophageal balloon?—yes. *Ann Transl Med* 6:392–405